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# Broadband Loaded Cylindrical Monopole Antenna

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**Abstract-** A broadband printed monopole antenna based on the variation of the conductivity along its length is proposed.. The result indicates that a non-monotonous repartition provides interesting performances in terms of impedance bandwidth but also concerning antenna gain. The achievement of the method is demonstrated through its application, using the carbon fibers to perform this conductivity variation. Monopole antenna presents a large impedance bandwidth of 123% with an interesting gain. Measurement and simulation present a good agreement.

## I. INTRODUCTION

With the rapid development of communication standards, wide band antennas are needed. Several authors have suggested widening monopole antenna bandwidth by resistive loading continually [1,2]. This kind of resistive distribution leads to a very wide bandwidth but damages significantly antenna gain and its efficiency becomes very low. Antenna characteristics could be improved by modifying the resistive profile.

In this paper, we propose to use a variable conductivity along the antenna length applying an optimized profile which gives a broadband impedance bandwidth, a stable radiation pattern, a stable gain level over a large bandwidth especially in the horizontal plane and a higher radiation efficiency. The values of conductivity used is achieved by using various materials such as copper and specially carbon fibers for which we can easily tune its conductivity by modifying the concentration of carbon nanofibers [3]. The main aim is to find a compromise between a large impedance bandwidth at -5 dB of reflection coefficient and a good efficiency. So, a new broadband monopole antenna is presented working in the VHF-UHF band. Simulation results and measurements are presented in order to illustrate the characteristics of the proposed antenna.

## II. ANTENNA DESIGN

The goal of our study is to broaden impedance bandwidth by varying the conductivity along the length of the monopole antenna and maintaining a stable gain level especially in horizontal plane ( $xOy$ ,  $\theta=0^\circ$ ). For this, we have used a multi-objective optimization software named mode Frontier<sup>®</sup>, Esteco coupled with a three-dimensional time domain

software named Microwave Studio<sup>®</sup>, CST. The selected method for optimization is based on a non-dominated sorting genetic algorithm [4]. The monopole antenna is composed of five equal segments length of 50 mm and 20 mm of diameter (figure 1).

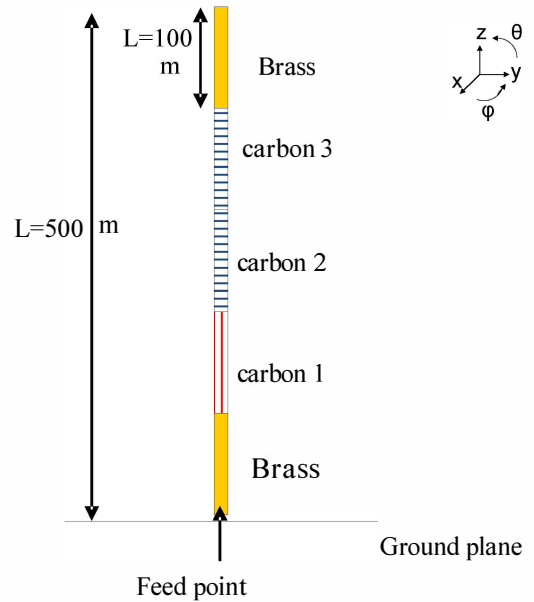


Fig 1. Monopole antenna geometry.

The first segment and last segment is made of Brass and the three other segments was made of carbon tubes.

The optimization solver suggests a distribution conductivity law with a minimum value placed not at the extremity of the monopole antenna as a classical Wu-King profile, but in its centre as shown in Table 1.

TABLE I  
CONDUCTIVITY VALUES

Segment	Conductivity (S/m)	Equivalent resistance ( $\Omega$ )
Carbon 1	2	159
Carbon 2	0.5	6294
Carbon 3	1,5	212

In Figure 2, we present the reflection coefficient of this antenna as well as the gain for  $\theta=0^\circ$  (horizontal plane).

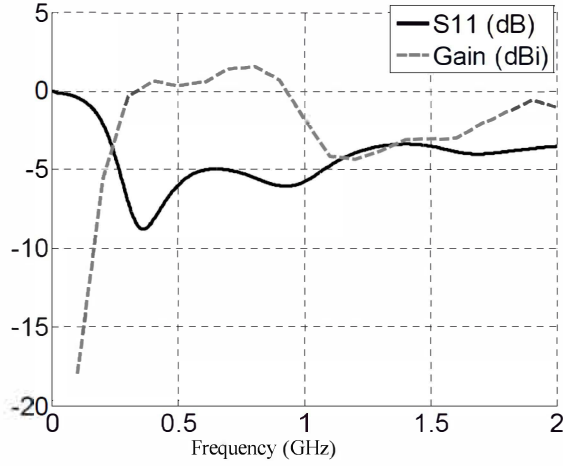


Fig 3. Simulation of monopole antenna reflection coefficient and gain in horizontal plane ( $\theta=0^\circ$ ) vs. frequency.

We can note that the gain level stays quite constant from 300 MHz to 900 MHz in the Oy axis direction. The maximum gain reaches a value of 2 dB. As for the impedance matching, we obtain 121% of bandwidth for -5 dB of reflection coefficient.

### III. MEASUREMENT RESULTS

A prototype has been realized. The five segments are held by a dielectric support and mounted on a circular ground plane of 800 mm of diameter as shown in Figure 3. It is fed by a coaxial cable fixed on a SMA connector soldered on the monopole antenna.

The carbon tubes are formed by winding on a mandrel fabric carbon fibers impregnated with resin, which is horizontally or vertically deposit on the tubular segment. On curing the resin, the reinforcing strip is integrated with the tubular member.



Fig 3. Picture of the realized antenna.

The obtained carbon segments (1-3) conductivity are : 468 SM, 3 S/m and 2 S/m respectively. Figure 4 shows monopole antenna reflection coefficient in simulation and in measurement using the new values. We note the conductivity values are different from the optimized value. We simulate again the prototype with the realized conductivity and compare results to measurements.

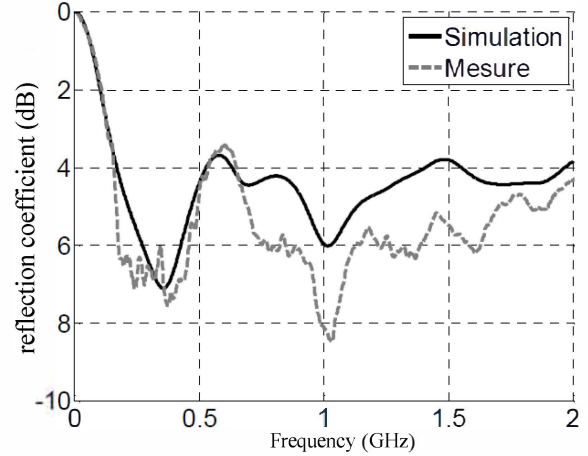


Fig 4. Simulated and measured reflection coefficients vs. frequency.

A double band behaviour at -6 dB of reflection coefficient is observed in Figure 4, starting at 180 MHz to 500 MHz GHz and from 650 MHz to beyond 1 GHz. We note a good agreement between simulation and measurement.

The radiation measurements were performed in an anechoic chamber. In Figures 5, we present at 300 MHz, 600 MHz and 900 MHz, the measured E-plane radiation patterns compared with the simulation.

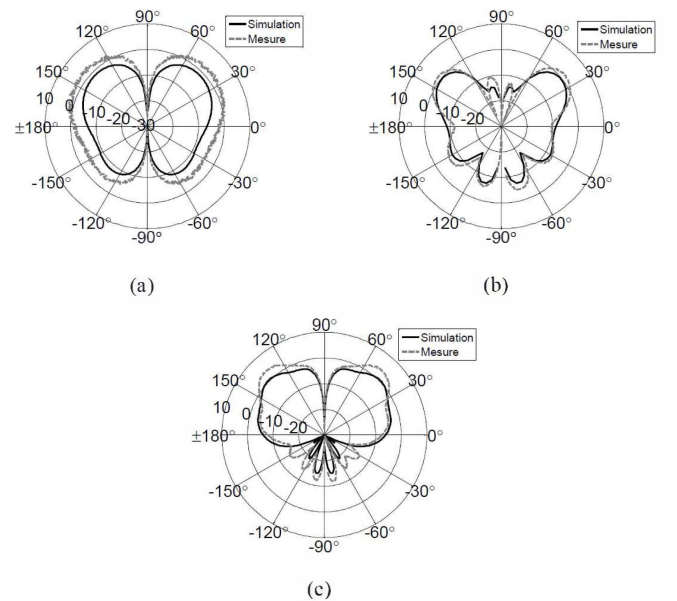


Fig 5. Simulated and measured radiation patterns in E plane at (a) 300 MHz, (b) 600 MHz and (c) 900 MHz

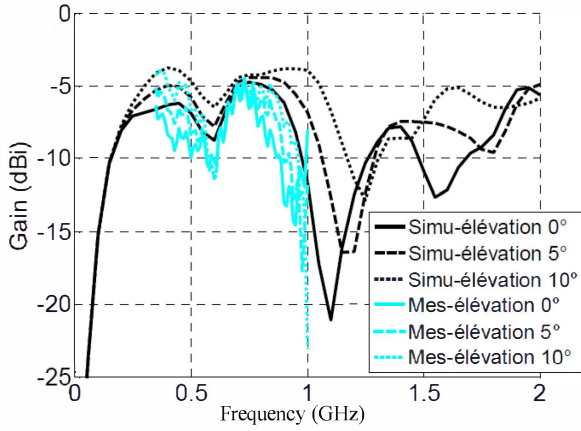


Fig 6. Simulated and measured realized gain vs. frequency for 3 elevations.

In figure 6, we present the measured and simulated gain for various values of elevation angle ( $\theta=0^\circ$ ,  $\theta=5^\circ$  and  $\theta=10^\circ$ ). We observe that gain value is quite stable for a more than 100% of bandwidth.

#### IV. CONCLUSION

A broadband monopole antenna has been fabricated in varying conductivity values along antenna length. Its impedance bandwidth is about 120% in VHF-UHF band if we realize the optimized value. Its gain in one direction has a correct level because of the introduction of high conductive material at feeding position.

#### ACKNOWLEDGMENT

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